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(54) **WOODWIND INSTRUMENT WITH KEY MECHANISM PERFECTLY CLOSING HOLES**

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(52) **U.S. Cl.** ..... **84/380 R**
(58) **Field of Search** ..... 84/380 R, 385 P, 84/385 A, 330

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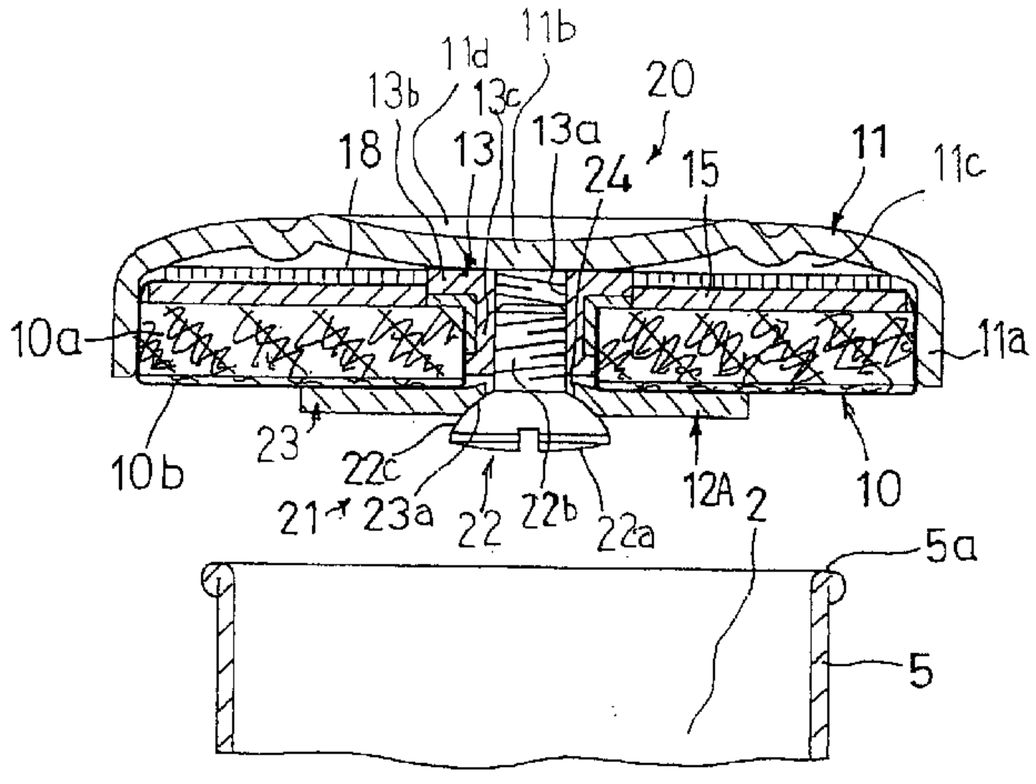
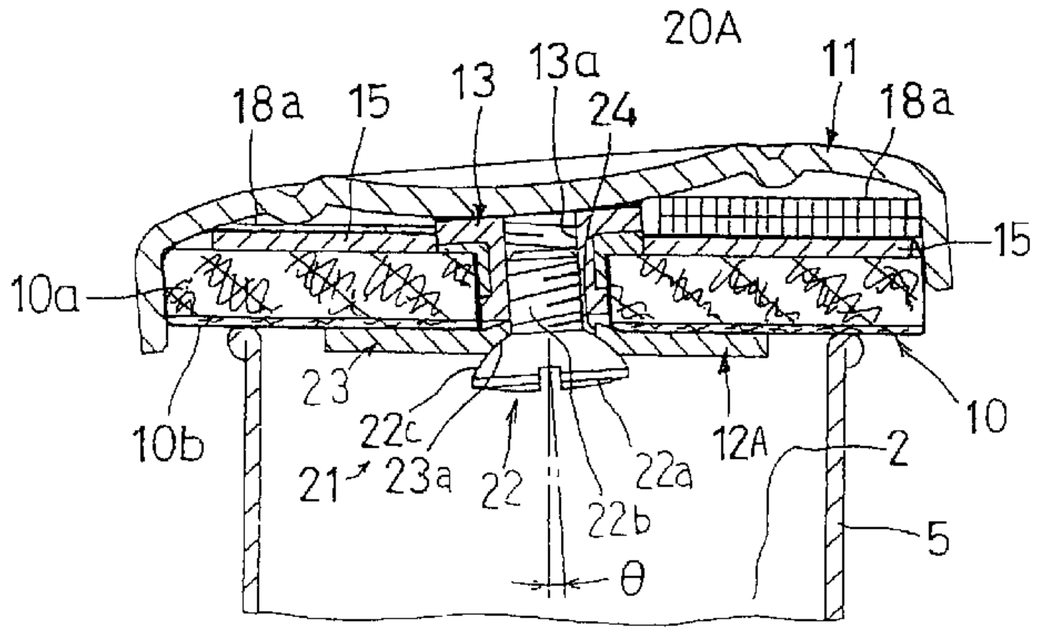
(57) **ABSTRACT**

A woodwind instrument has a key mechanism provided on a tube, and a player selectively closes and opens holes formed in the tube through a fingering; the key mechanism includes keys corresponding to the holes, and each of the key has an automatic regulator for uniformly pressing a pad washer to a pad received in a pad cup so that, even if the pad cup is inaccurately fixed to a linkage of the key mechanism, the hole is surely closed with the pad.

17 Claims, 3 Drawing Sheets





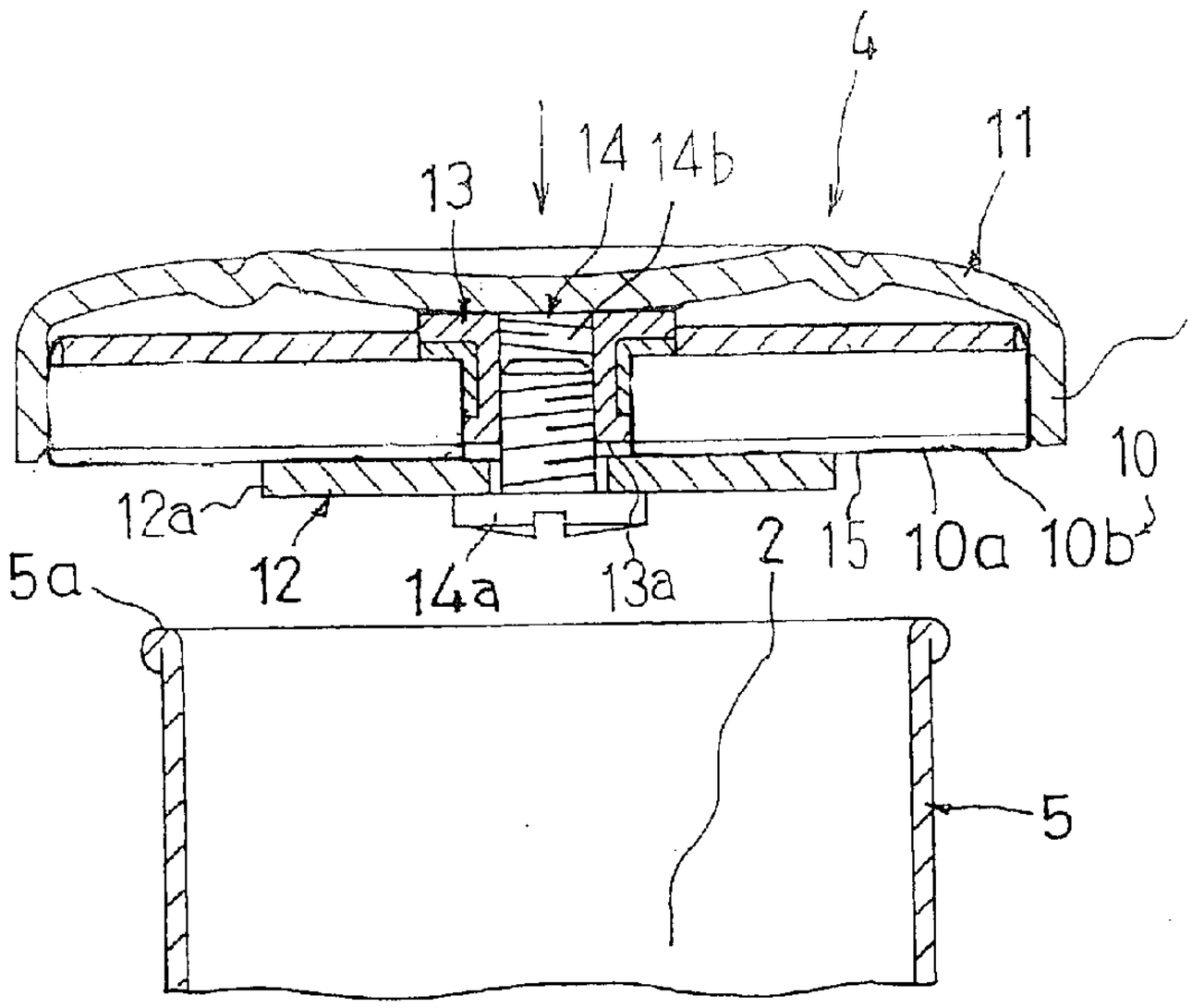


Fig. 1
PRIOR ART

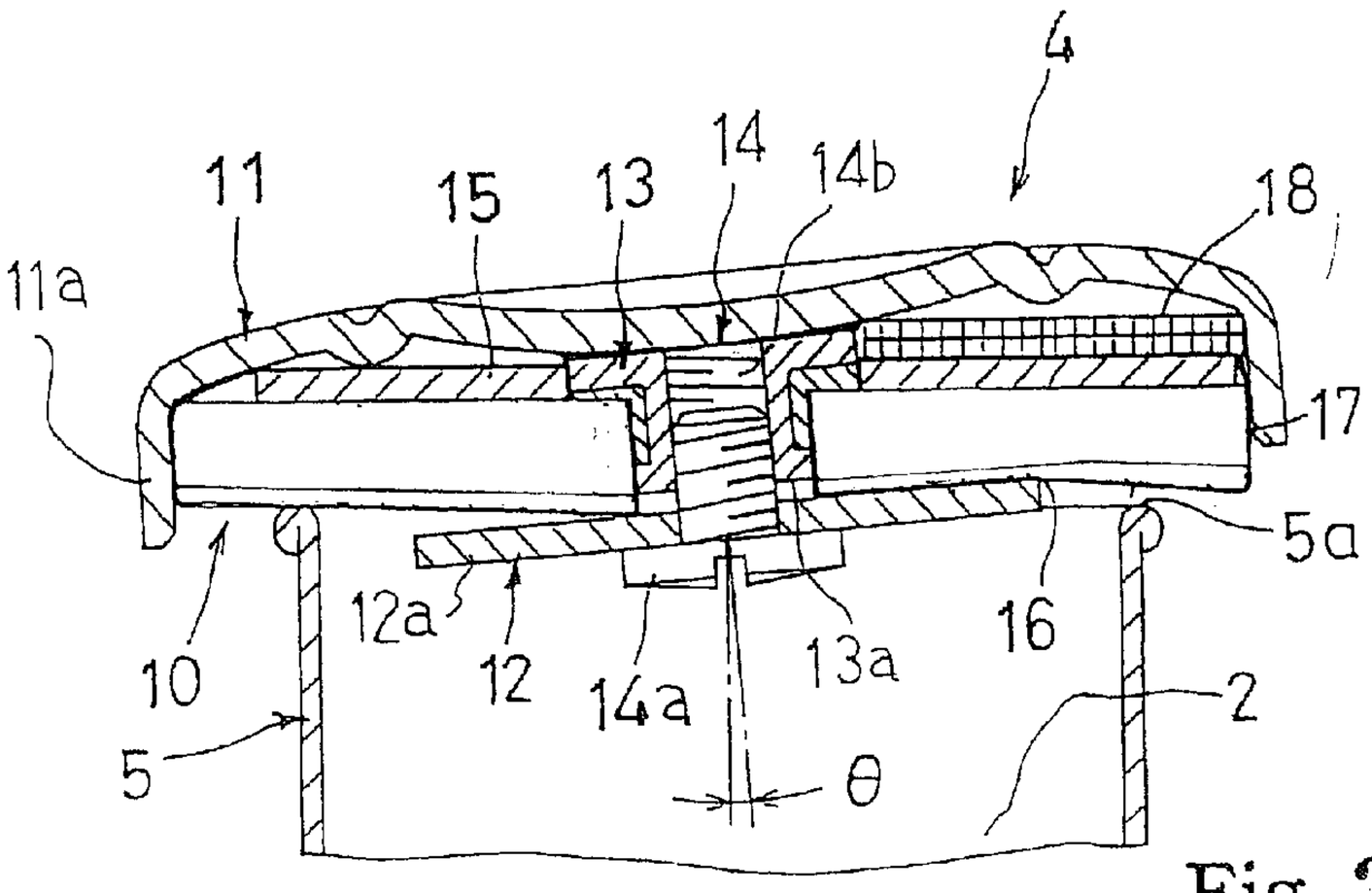


Fig. 2
PRIOR ART

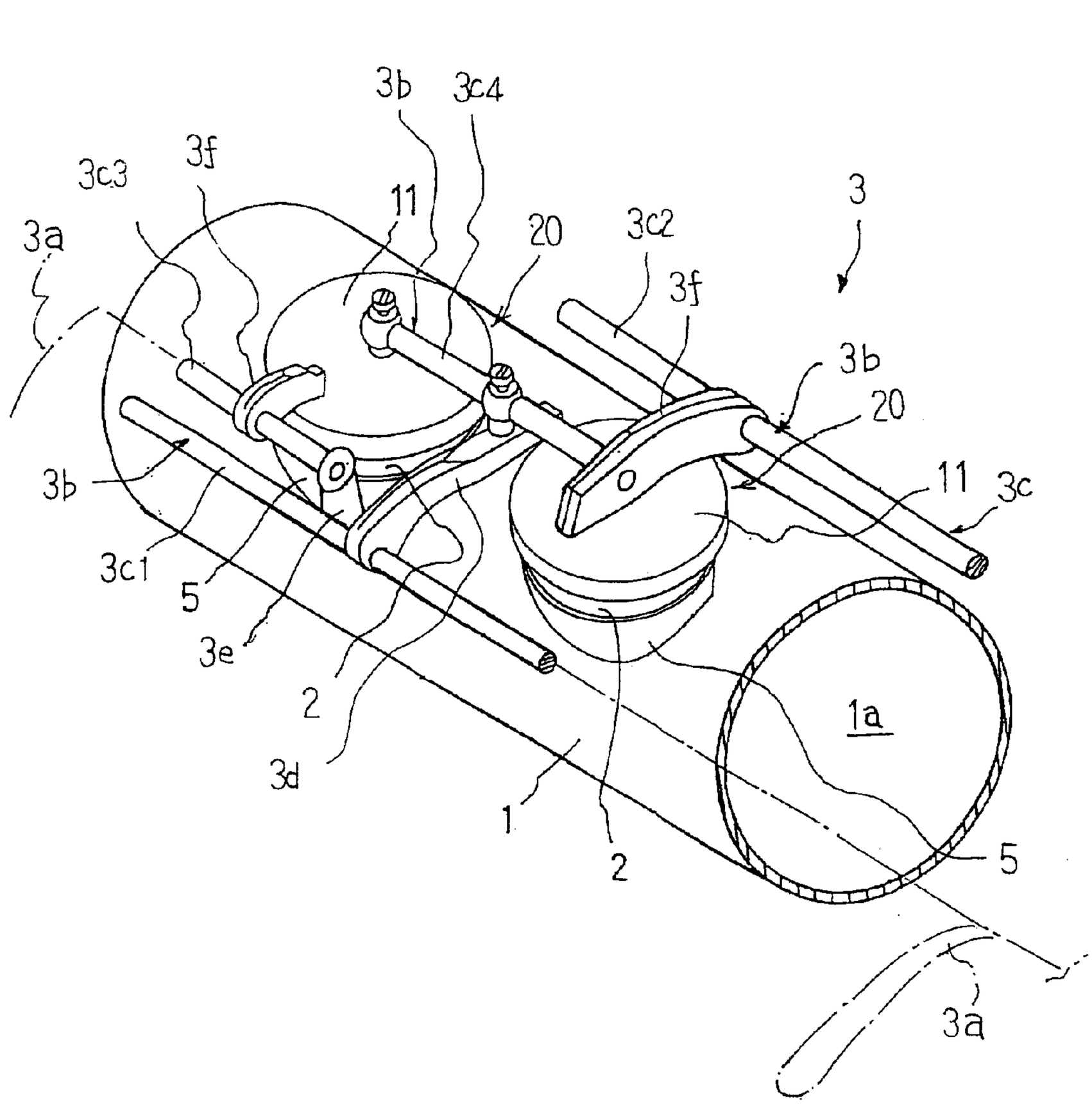


Fig. 3

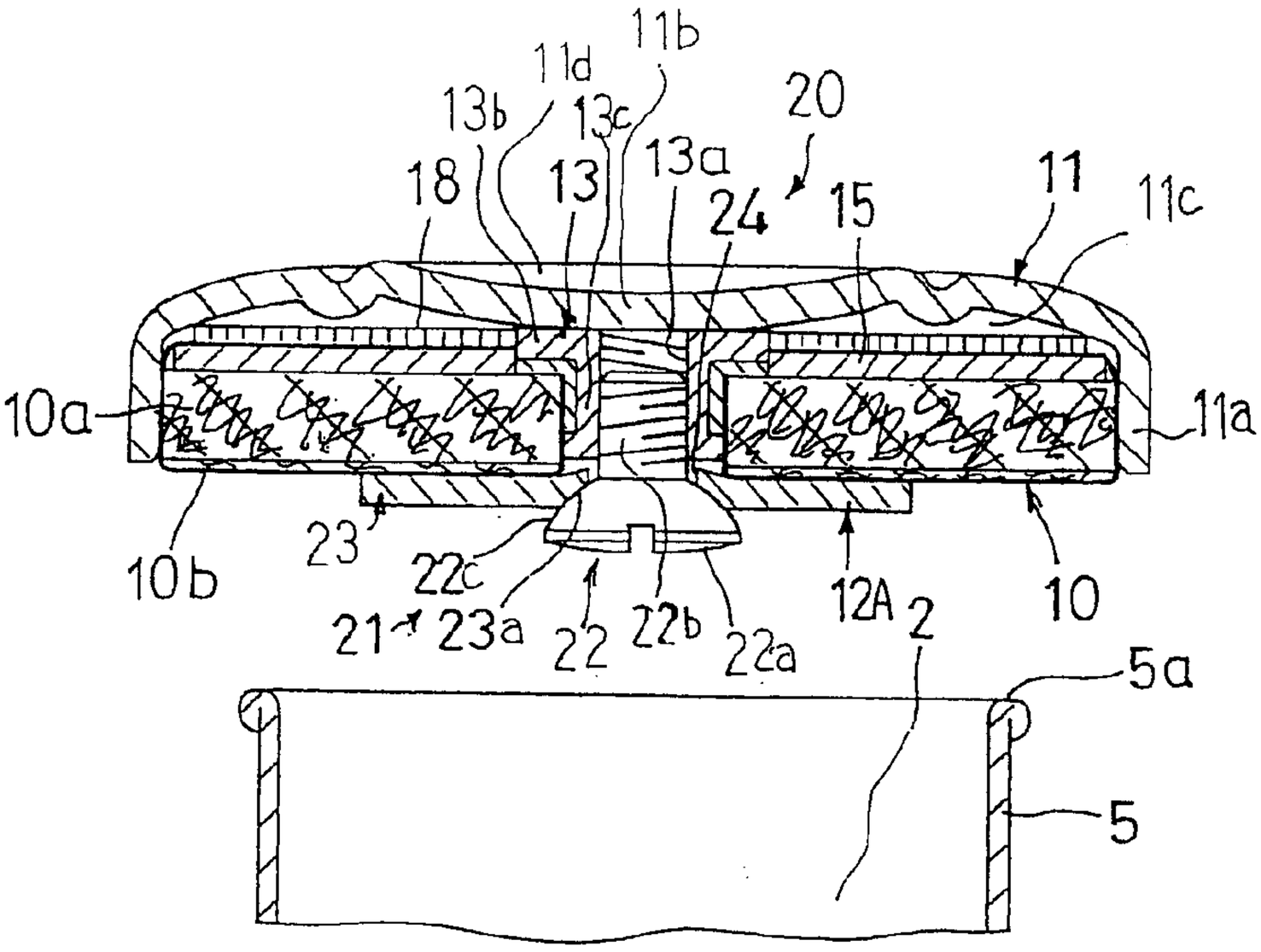

11b
11d
13b
13c
20
13a
18
13
24
15
11
11c
10a
11a
23
22c
21
23a
22
22b
22a
12A
2
10
10b
5a
5

Fig. 4

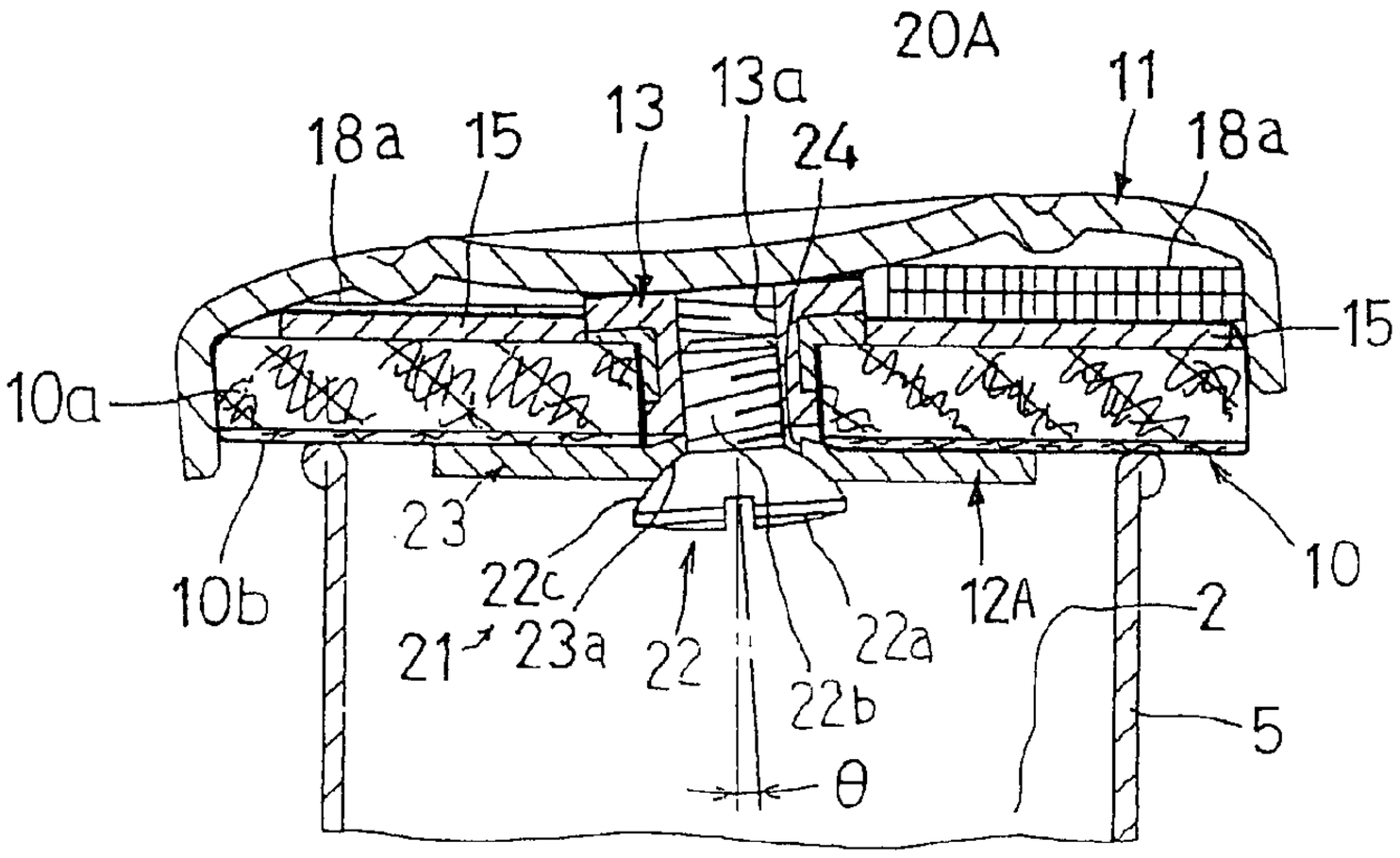

20A
18a
15
13
13a
24
11
18a
15
10a
23
22c
21
23a
22
22b
22a
12A
2
10
10b
5
θ

Fig. 5

WOODWIND INSTRUMENT WITH KEY MECHANISM PERFECTLY CLOSING HOLES

FIELD OF THE INVENTION

This invention relates to woodwind instrument and, more particularly, those types of woodwind instrument equipped with key mechanisms for closing holes formed in tubes.

DESCRIPTION OF THE RELATED ART

The woodwind instrument has a wide variety of family members such as, for example, flutes, recorders, clarinets, oboes, saxophones and bassoons. Although the word "woodwind" is a compound word produced from the words "wood" and "wind", the word "woodwind" does not imply the material of the wind instruments. The bassoons and clarinets are usually made of wood. However, the saxophones are made of metal. Several family members such as flutes are directly blown by players. On the other hand, players require reeds for other family members. The players blow the clarinets by means of reeds, by way of example. Although the players give rise to vibrations of air columns in different manners, they are the family members of the woodwind instrument. Nevertheless, all the family members of woodwind instrument have tubes formed with holes, and the players selectively open and close the holes for changing the pitch of notes emitted. The tubes of recorders are not so long that the players can selectively open and close the holes with their fingers. However, the flutes, saxophones, oboes and bassoons have the tubes formed with the holes, which are widely spaced from one another. The intervals are too long for the players to selectively open and close them with their fingers. For this reason, these family members require unique key mechanisms. The present invention appertains to those family members of the type having the key mechanisms.

A flute is, by way of example, broken down into a tube, which may be separable into plural parts, and a key mechanism. The tube is formed with a mouthpiece and holes. The mouthpiece is formed at one end portion of the tube, and the holes are arranged along the centerline of the tube toward the other end. The key mechanism includes plural keys, with which a player selectively opens and closes the holes for changing the pitch of tones.

FIG. **2** illustrates the prior art key **4** incorporated in the flute. The prior art key **4** is broken down into a pad **10**, a pad cup **11** and a fastener **12**. The pad cup **11** is formed of metal or alloy, and has a recess where the pad **10** is snugly received. The fastener **12** prohibits the pad **10** from being unintentionally separated from the pad cup **11**. A tone hole chimney **5** encircles one of the holes **2** formed in the tube, and the upper edge **5***a* of the tone hole chimney **5** is rounded. The pad **10** is pressed to the rounded edge **5***a* for closing the hole **2**.

The pad **10** is to be air-tight, adaptable and durable. While a player is playing on the flute, the moist breath passes through the tube, and vents through the hole **2**, which the player keeps opened. The pads **10** are expected to confine the wet air in the tube. If the breath is leaked through the pads **10**, the tones become unstable, and the player feels the pitches, loudness and timbre less controllable. In order hermetically to seal the breath in the tube, the pads **10** are expected to adapt themselves to the holes **2**. Thus, the pads **10** are to be adaptable and airtight.

The pads **10** are exposed to the wet air during the practice and performance. Although the player wipes the condensate from the inner wall of the tube **1** after the practice, the condensate is liable to be left on the pads **10**. The pads **10** are dried until the next practice/performance. Thus, the pads **10** are repeatedly exposed to the wet air and dried thereafter. Nevertheless, the pads **10** are expected to maintain the adaptability and the air-tightness. If the pads **10** lose the adaptability and air-tightness within a short time, the player frequently changes the pads **10** from the waste ones to new pieces. The exchange work is time-consuming, and players hate it. For this reason, the pads **10** are to be durable.

From those viewpoints, the pad **10** is designed to have a core **10***a*/**15** and a sealing layer **10***b*. The core **10***a*/**15** imparts the adaptability to the pad **10**, and the sealing layer **10***b* makes the pad **10** airtight. A core layer **10***a* and a backing cardboard **15** as a whole constitute the core. The backing cardboard **15** is made of paper, and the core layer **10***a* is made of air-permeable material such as compression felt. The core layer **10***a* is laminated on the backing cardboard **15**, and sealing layer **10***b* is fixed to the core layer **10***a* reverse to the backing cardboard **15**. The sealing layer **10***b* is expected to hermetically seal the air column inside the tube. Skin and bladder are available for the sealing layer **10***b*. It is preferable to make the sealing layer **10***b* from sheepskin, calfskin and bladder of sheep and calf. The pad **10** is formed with a center hole. The center hole is increased in diameter from the core/sealing layers **10***a*/**10***b* to the backing cardboards **15** so that a step takes place at the boundary between the backing cardboard **15** and the core layer **10***a*.

The pad cups **11** are formed from a sheet of metal/alloy through a drawing. Each of the pad cups **11** has a peripheral wall portion **11***a* so as to define the recess. The recess has an inner diameter substantially equal to the outer diameter of the pad **10** so that the pad **10** is snugly received in the recess. However, the recess has the depth greater than the thickness of the pad **10**. A player directly depresses the pad cups **11** with his or her fingers, and pushes levers, which are connected through shafts to the other pad cups **11**, with his or her thumb and fingers for closing the holes **2**. When the player removes the force from the pad cups **11** or the levers, return springs make the pad cups **11** open.

The fastener **12** consists of a center nut **13**, a bolt **14** and a circular plate **12***a*. The center nut **13** is brazed to the inner surface of the pad cup **11**, and an internal thread is formed along the centerline of the center nut **13**. The center nut **13** has an end surface **13***a* where the internal thread is open, and the end surface **13***a* is flat. The center nut **13** has a wide boss portion substantially equal in diameter to the hole formed in the backing cardboard **15**, and the remaining portion is substantially equal in diameter to the hole passing through the core layer **10***a* and the sealing layer **10***b*. Thus, the center nut **13** is snugly received in the center hole of the pad **10**.

The bolt **14** has a head portion **14***a* and a threaded stem portion **14***b*, and the threaded stem portion **14***b* projects from the reverse surface of the head portion **14***a*. The reverse surface of the head portion **14***a* is also flat.

The circular plate **12***a* has major surfaces, which are also flat, and is formed with a hole at the center area thereof. The hole in the circular plate **12***a* has an inner diameter greater than the outer diameter of the threaded stem portion **14***b* so that the threaded stem portion **14***b* loosely passes through the hole formed in the circular plate **12***a*. The circular plate **12***a* has an outer diameter less than the outer diameter of the pad **10** and, accordingly, the inner diameter of the recess.

The key **4** is assembled as follows. An assembling worker puts the pad **10** into the recess. The center nut **13** is inserted

into the center hole of the pad **10**, and the flat end surface **13***a* is inside the center hole. Subsequently, the assembling worker puts the circular plate **12***a* on the sealing layer **10***b*, and aligns the hole formed in the circular plate **12***a* with the hole formed in the center nut **13**. The assembling worker inserts the threaded stem portion **14***b* into the center nut **13**, and turns the bolt **14**. The threaded step portion **14***b* is brought into threaded engagement with the center nut **13**, and the bolt **14** is screwed into the center nut **13**. The flat reverse surface of the head portion is brought into face-to-face contact with the flat major surface of the circular plate **12***a*, and the head portion **14***a* is pressed against the circular plate **12**. The circular plate **12***a* in turn presses the pad **10** to the boss portion of the center nut **13**. Thus, the pad **10** is fastened to the pad cup **11** by means of the fastener **12**.

Assuming now that the pad cup **11** was mistakenly brazed to the arm, the center line of the column **13** is inclined with respect to the centerline of the tone hole chimney **5** by θ as shown in FIG. **2**. If the pad **10** is fastened to the pad cup **11** without any regulation, the pad **10** is also inclined with respect to the centerline of the tone hole chimney **5**. When a player depresses the key **4** to the tone hole chimney **5**, the pad **10** is imperfectly brought into contact with the upper edge **5***a*, and clearance takes place between the pad **10** and the tone hole chimney **5**. This results in leakage of the breath. For this reason, if the angle θ is not serious, the assembling worker tries to regulate the pad **10** to the appropriate position.

The assembling worker inserts an adjusting shim **18** between the backing cardboard **15** and the pad cup **11**. The adjusting shim **18** is made of paper, and makes the pad **10** spaced from a certain area on the inner surface of the pad cup **11**. If the pad **10** is appropriately regulated by means of the adjusting shim **18**, the centerline of the tone hole chimney **5** is normal to the pad **10**, and the pad **10** is brought into contact with the entire upper edge of the tone hole chimney **5**. The pad **10** prevents the hole **2** from leakage of the breath. However, a problem is encountered in the prior art keys **4** in that the breath is still leaked through some holes **2** after the regulating work.

SUMMARY OF THE INVENTION

It is therefore an important object of the present invention to provide a woodwind instrument, a key mechanism of which perfectly close and open holes formed in a tube after a regulating work.

The present inventors investigated the problem inherent in the prior art key, and found that the circular plate **12***a* was strongly pressed against the certain portion of the pad **10** where the adjusting shim **18** had been inserted. A dent was formed in the certain portion, and gap **17** took place between the upper edge **5***a* and the pad **10** in the vicinity of the dent. The breath was leaked through the gap **17**.

The present inventors reasoned from the structure of the prior art key **4** as follows. The center nut **13** was inclined with respect to the centerline of the tone hole chimney **5**, and the pad **10** and circular plate **12***a* were perpendicular to the centerline of the tone hole chimney **5** under the condition that any force was not exerted on the circular plate **12***a*. Since the bolt **14** was screwed into the inclined center nut **13**, the head portion **14***a* proceeds toward the circular plate **12***a* along the inclined centerline of the center nut **13**. The flat reverse surface of the head portion **14***a* was partially brought into contact with the certain area in the flat surface of the circular plate **12***a*. The head portion **14***a* exerted the force on the certain area, and caused the circular plate **12***a* to be inclined with respect to the centerline of the tone hole chimney **5**. This resulted in the face-to-face contact between the flat reverse surface of the head portion **14***a* and the flat surface of the circular plate **12***a*. Since the head portion **14***a* uniformly exerted the force on the flat surface of the circular plate **12***a*, the circular plate **12***a* was forced to move along the inclined centerline of the center nut **13**. Although the pad **10** resisted against the circular plate **12***a*, the sealing/core layers **10***b*/**10***a* was deformable so that the circular plate **12***a* made the dent in the pad **10**. The present inventors concluded that the dent and, accordingly, the clearance were resulted from the circular plate **12***a*, which changed the attitude when the head portion **14***a* was brought into contact therewith.

To accomplish the object, the present invention proposes automatically to regulate a pad washer to be in parallel to a pad while a bot is being screwed into a center nut.

In accordance with one aspect of the present invention, there is provided a woodwind instrument for generating tones through a vibrating column of air comprising a tube having an inner space where the vibrating column of air takes place and plural holes connecting the inner space to the atmosphere and a key mechanism including a linkage fixed to the tube and plural keys supported by the linkage over the plural holes and changed between respective open positions at which the holes are opened and respective closing positions at which the holes are closed, and each of the keys has a pad cup connected to the linkage and formed with a recess, a deformable pad received in the recess and held in contact with a periphery of the tube defining associated one of the holes at the closing position, a adjusting shim inserted between the pad cup and the deformable pad, if necessary, in order to cause the deformable pad to be held in contact with the entire periphery of the tube defining the associated one of the holes at the closing position, a fastener connected to the pad cup and exerting force on the pad for pressing the deformable pad and the adjusting shim, if any, to the pad cup and an automatic regulator provided in association with the fastener and causing the force to be substantially uniform over a contact surface between the fastener and the deformable pad.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the woodwind instrument will be more clearly understood from the following description taken in conjunction with the accompanying drawings, in which

FIG. **1** is a cross sectional view showing the structure of the key incorporated in the prior art flute,

FIG. **2** is a cross sectional view showing the center nut mistakenly brazed to the pad cup,

FIG. **3** is a perspective view showing the arrangement of a part of key mechanism incorporated in a flute,

FIG. **4** is a cross sectional view showing the structure of a key incorporated in the flute, and

FIG. **5** is a cross sectional view showing a pad washer regulated to be parallel to a pad by means of an automatic regulator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **3** of the drawings, a flute embodying the present invention comprises a tube **1** and a key mechanism **3**. An inner space **1***a* is defined in the tube **1**, and the tube **1** is formed with a mouthpiece (not shown) and holes **2**. The

mouthpiece is open to the atmosphere at one end portion of the tube **1**, and the holes **2** are arranged toward the end portion. In the following description, term "upstream" is indicative of a position key to the mouthpiece than a position modified with term "downstream". Namely, the holes **2** are arranged from the upstream side toward the downstream side along the tube **1**. The inner space **1***a* is open to the atmosphere at the other end thereof, and is connected through the holes **2** to the atmosphere. The hole at the other end of the tube **1** is hereinbelow referred to as "end hole" in order to discriminate it from the holes **2**.

The key mechanism **3** is provided on the tube **1**, and a player selectively opens and closes the holes **2** by manipulating the key mechanism. The holes **2** are assigned to the notes of a scale, respectively, and the length of the air column is defined by the end hole or an open hole **2** closest to the mouthpiece. Thus, the player selectively changes the pitch of tones by means of the key mechanism **3**.

The key mechanism **3** includes plural levers **3***a,* transmission devices **3***b* and keys **20**. In this instance, the plural levers **3***a* and transmission devices **3***b* as a whole constitute a linkage. Key rods **3***c* such as **3***c***1**/**3***c***2**/**3***c***3**/**3***c***4**, arms **3***d*/**3***f* and key posts **3***e* are assembled into the transmission devices **3***b*. The key posts **3***e* are fixed to the outer surface of the tube **1**, and the key rods **3***c* such as **3***c***1**/**3***c***3** are rotatably supported by the associated key posts **3***e*. The levers **3***a* are connected to selected ones of the key rods **3***c,* and return springs (not shown) always urge the key rods **3***c* to rotate in certain directions.

The keys **20** are selectively fixed to the key rods **3***c* by means of the arms **3***f,* and are associated with the holes **2**, respectively. Tone hole chimneys **5** are fixed to the outer surface of the tube **1** in such a manner as to encircle the holes **2**. The tone hole chimneys **5** form parts of the tube **1**. Although the return springs (not shown) urge the key rods **3***c* to keep the keys **20** spaced from the tone hole chimneys **5**, a player brings the keys **20** into contact with the upper peripheral edges of the tone hole chimneys **5** by exerting force on the levers **3***a* or directly on the keys **20** with his or her thumb and fingers.

Some key rods **3***c* are in a master-slave relation. Although these key rods **3***c* are coupled to the associated key rods **3***c,* the rotation is transmitted only from the master key rods **3***c,* which are driven for rotation by a player, to the slave key rods, but is not transmitted vise versa. The arms **3***d* are fixed to the certain key rods **3***c,* and are connected to other key rods **3***c* at the other ends thereof. The arms **3***d* transmit torque from the certain key rods **3***c* to the other key rods **3***c* so that the player can concurrently actuate plural transmission devices **3***b* by manipulating only one lever **3***a*. The master-slave key rods **3***c* and arms **3***d* permit a player sequentially to space the keys **20** from the holes **2** so as stepwise to change the pitch of the tones.

While a player is performing a piece of music on the flute, he or she breathes the air into the mouthpiece, and gives rise to vibrations of air column. The player tongues, and selectively opens and closes the holes **2** through the key mechanism **3**. The vibrating air column is shortened and lengthened in response to the fingering on the key mechanism **3**, and, accordingly, the pitch of tones is changed.

FIG. **4** illustrates one of the keys **20** incorporated in the key mechanism **3**. The key **20** is of the type directly depressed by a player. The key **20** includes a pad cup **11**, a pad **10**, a fastener **12**A and an automatic regulator **21**. Thus, the automatic regulator **21** is newly incorporated in the key **20**. The pad **10** is fastened to the pad cup **11** by means of the fastener **12**A. The automatic regulator **20** is provided between the fastener **12**A and the pad **10**, and makes the fastener **12**A uniformly depress the pad **10** to the pad cup **11** regardless of the attitude of the fastener **12**A.

The pad cup **11** is formed from a sheet of metal or alloy through a drawing. The pad cup **11** has a peripheral portion **11***a* and a central portion **11***b*. The peripheral portion **11***a* is curved from the central portion **11***b* so that the inner surface defines a recess **1***c*. The pad **10** and fastener **12** are provided in the recess **11***c*. The central portion **11***b* further defines a shallow dent **11***a* in the outer surface, and the player puts his or her finger in the dent **11***d* during the performance.

The pad **10** is also broken down into a core **10***a*/**15** and a sealing layer **10***b*. The core **10***a*/**15** imparts the adaptability to the pad **10**, and the sealing layer **10***b* makes the pad **10** airtight. A core layer **10***a* and a backing cardboard **15** as a whole constitute the core. The backing cardboard **15** is made of paper, and the core layer **10***a* is made of air-permeable material such as, for example, compression felt. The core layer **10***a* is laminated on the backing cardboard **15**, and sealing layer **10***b* is fixed to the core layer **10***a* reverse to the backing cardboard **15**. The sealing layer **10***b* is expected to hermetically seal the air column inside the tube **1**. Skin and bladder are available for the sealing layer **10***b*. It is preferable to make the sealing layer **10***b* from sheepskin, calfskin and bladder of sheep and calf. The pad **10** is formed with a center hole. The center hole is wider in the backing cardboards **15** than in the core/sealing layers **10***a*/**10***b*.

The fastener **12**A consists of a center nut **13**, a bolt **22** and a pad washer **23**. The center nut **13** is brazed to the inner surface of the pad cup **11**, and an internal thread **13***a* is formed in the center nut **13** along the centerline thereof. The center nut **13** has a boss portion **13***b* and an end portion **13***c*. The boss portion **13***b* is held in contact with the inner surface of the central portion **11***b,* and is brazed thereto. The end portion **13***c* projects from the boss portion **13***b,* and the height of the center nut **13** is not greater than the depth of the recess **11***c*. The boss portion **13***b* is approximately equal in diameter to the hole formed in the backing cardboard **15**, and the end portion **13***c* is approximately equal in diameter to the core/sealing layer **10***a*/**10***b*. When the central column **13** is inserted into the center hole of the pad **10**, the step at the boundary between the boss portion **13***b* and the end portion **13***c* is brought into face-to-face contact with the step at the boundary between the backing cardboard **15** and the core/sealing layers **10***a*/**10***b* so as to keep the pad **10** substantially perpendicular to the centerline of the center nut **13**. In this instance, the thickness of the pad **10** is less than the depth of the recess **11***c,* and a liner **18** is inserted between the pad **10** and the inner surface of the pad cup **11**.

The bolt **22** is broken down into a head portion **22***a* and a threaded stem portion **22***b*. The bolt thread on the threaded stem portion **22***b* is corresponding to the inner thread **13***a,* and the bolt thread and the inner thread **13***a* are brought into threaded engagement with one another. The head portion **22***a* is different from the head portion of the bolt **14***a*. Although the reverse surface of the head portion **14***a* is flat, the head portion **22***a* has a convex surface **22***c*. In this instance, the convex surface forms a part of sphere so that the convex surface **22***c* is a semi-spherical surface **22***c*.

The pad washer **23** has a disc shape, and is made of metal or alloy. The pad washer **23** has the outer diameter less than the outer diameter of the pad **10**. When the pad washer **23** is put on the pad **10**, the periphery of the pad washer **23** is spaced from the peripheral portion **11***a* of the pad cup **11**.

The pad washer **23** is also different from the pad washer **12***a*. The pad washer **12***a* has the flat major surfaces. On the

other hand, the pad washer **23** has a concave surface or a curved surface **23***a,* which defines a semi-spherical recess. The curved surface **23***a* forms a part of the sphere. The curved surface **23***a* is corresponding to the semi-spherical surface **22***c* of the head portion **22***a*. The pad washer **23** is formed with a hole **24**, and the hole **24** is greater in diameter than the threaded stem portion **22***b*. For this reason, the threaded stem portion **22***b* loosely passes through the hole **24**.

The curved surface **23***a* is formed by pressing a steel ball against the inner peripheral area around the hole **24**, and a part of the outer surface of the steel ball is identical with the semi-spherical surface **22***c*. The curved surface **23***a* and the semi-spherical surface **22***c* have a radius of curvature ranging between 1 millimeter to 10 millimeters. It is more preferable that the radius of curvature is fallen within the range between 1.5 millimeters to 5 millimeters. The semi-spherical surface **22***c* and the curved surface **23***a* as a whole constitute the automatic regulator **21**. Thus, the automatic regulator **21** is associated with the fastener **12**A.

The pad cup **11**, pad **10**, fastener **12**A and automatic regulator **21** are assembled into the key **20** as follows. First, the pad cup **11** is assumed to have been correctly brazed to the arm **3***f*. Namely, the centerline of the center nut **13** is normal to the pad **10** and pad cup **11**, and is in parallel to the centerline of the tone hole chimney **5**. An assembling worker inserts the center nut **13** into the hole of the liner **18** and the center hole of the pad **10** so as to laminate the linear **18** and pad **10** on the inner surface of the pad cup **11**. The assembling worker puts the pad washer **23** on the pad **10**, and aligns the hole **24** with the hole in the center nut **13**. The pad washer **23** takes the appropriate attitude, i.e., in parallel to the pad **10**.

The bolt **22** is screwed into the center nut **13**. The semi-spherical surface **22***c* is brought into contact with the curved surface **23***a,* and presses the pad washer **23** to the pad **10**. Since the pad cup **11** has been correctly brazed to the arm **3***f,* the semi-spherical surface **22***c* imparts the pressure uniformly to the pad washer **23** over the contact area in the curved surface **23***a,* and the pad washer **23** presses the pad **10** and liner **18** against the pad cup **11** without changing the initial attitude. Thus, the automatic regulator **21** keeps the pad washer **23** in the initial appropriate attitude in so far as the pad cup **11** was correctly brazed to the arm **3***f*.

If the pad cup **11** was mistakenly brazed to the arm **3***f,* the centerline of the column **13** is inclined with respect to the centerline of the tone hole chimney **5** as shown in FIG. **5**. The assembling worker inserts a adjusting shim **18***a* between the pad **10** and the inner surface of the pad cup **11**, and makes the pad **10** perpendicular to the centerline of the tone hole chimney **5**. The assembling worker puts the pad washer **23** on the pad **10**, and aligns the hole **24** with the center hole of the pad **10**. The pad washer **23** takes the attitude parallel to the pad **10**.

The assembling worker screws the bolt **22** into the center nut **13**. The bolt head **22***a* proceeds toward the pad washer **23** along the inclined centerline of the center nut **13**. The semi-spherical surface **22***c* is brought into contact with the entire curved surface **23***a*. This is because of the fact that the semi-spherical surface **22***c* has the radius of curvature equal to that of the curved surface **23***a*. The assembling worker further screws the bolt **22** into the center nut **13**, and the semi-spherical surface **22***c* exerts the force to the entire curved surface **23***a* of the pad washer **23**. The pad washer **23** does not change the initial attitude, and presses the pad **10** and adjusting shim **18***a* against the inner surface of the pad cup **11**. Thus, the automatic regulator **21** causes the pad washer **23** to keep the initial attitude, and any dent does not take place in the pad **10**. This means that the pad **10** is brought into contact with the entire rounded periphery **5***a* of the tone hole chimney **5**. The key **20** surely confines the vibrating column of air in the tube **1**, and the pitch, loudness and timbre do not fluctuate during the performance.

As will be appreciated from the foregoing description, the automatic regulator **21** according to the present invention is provided in association with the fastener **12**A, and regulates the attitude of the pad washer **21** always to be in parallel to the pad **10** regardless of the connection between the pad cup **11** and the fastener **12**A. The fastener **12**A exerts force uniformly on the pad **10** so that any dent does not take place in the pad **10**. Even if the center nut **13**, i.e., the fastener **22** is inaccurately fixed to the pad cup **11**, the automatic regulator **21** takes up the inaccuracy, and the fastener **12**A can exerts the force uniformly on the pad **10** as if the fastener **22** has been accurately fixed to the pad cup **11**. By virtue of the automatic regulator **21**, the fastener **12**A holds the exposed surface of the pad **10** flat, and the key **20** surely opens and closes the holes **2** in response to the fingering on the key mechanism **3** during the performance.

Although particular embodiments of the present invention have been shown and described, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the present invention.

For example, the center nut **13** may be integral with the pad cup **11**.

Another automatic regulator may have a bolt formed with the curved surface **23***a* and a pad washer formed with the semi-spherical surface **22***c* around the bolt hole **24**.

Yet another automatic regulator may have a bolt formed with either semi-spherical or curved surface **22***c*/**23***a* and a pad washer formed with a ring. The ring is slidable on the semi-spherical surface **22***c* and the curved surface **23***c* so that the automatic regulator keeps the attitude of the pad washer substantially in parallel to the pad. The ring may be replaced with plural small semi-spherical projections. The small semi-spherical projections are also slidable on the semi-spherical surface **22***c* and curved surface **23***a*.

Still another automatic regulator may have a pad washer formed with either semi-spherical or curved surface **22***c*/**23***a* and a bolt formed with a ring. The ring is slidable on the semi-spherical surface **22***c* and the curved surface **23***c* so that the automatic regulator keeps the attitude of the pad washer substantially in parallel to the pad. The ring may be replaced with plural small semi-spherical projections. The small semi-spherical projections are also slidable on the semi-spherical surface **22***c* and curved surface **23***a*.

What is claimed is:

1. A woodwind instrument for generating tones through a vibrating column of air, comprising:

a tube having an inner space where said vibrating column of air takes place and plural holes connecting said inner space to the atmosphere; and

a key mechanism including a linkage fixed to said tube and plural keys supported by said linkage over said plural holes and changed between respective open positions at which said holes are opened and respective closing positions at which said holes are closed,

each of said keys having

a pad cup connected to said linkage and formed with a recess,

a deformable pad received in said recess and held in contact with a periphery of said tube defining associated one of said holes at said closing position,

a adjusting shim inserted between said pad cup and said deformable pad, if necessary, in order to cause said deformable pad to be held in contact with the entire periphery of said tube defining said associated one of said holes at said closing position,

a fastener connected to said pad cup and exerting force on said deformable pad for pressing said deformable pad and said adjusting shim, if any, to said pad cup and

an automatic regulator provided in association with said fastener and causing said force to be substantially uniform over a contact surface between said fastener and said deformable pad.

2. The woodwind instrument as set forth in claim **1**, in which said fastener includes

a column formed with an internal thread and connected to said pad cup in such a manner to project into said recess,

a pad washer provided on said deformable pad and formed with a hole and

a bolt having a head portion to be driven for rotation and a threaded stem portion loosely passing through said hole formed in said pad washer and held in threaded engagement with said internal thread so that said head portion is pressed to said pad washer.

3. The woodwind instrument as set forth in claim **2** in which said head portion and said pad washer respectively have a convex surface and a concave surface portion around said hole slidably in contact with said convex surface, and said convex surface and said concave surface portion as a whole constitute said automatic regulator.

4. The woodwind instrument as set forth in claim **3**, in which said concave surface and said concave surface portion form parts of a sphere, respectively.

5. The woodwind instrument as set forth in claim **4**, in which said sphere has a radius of curvature fallen within the range from 1 millimeter to 10 millimeters.

6. The woodwind instrument as set forth in claim **4**, in which said sphere has a radius of curvature fallen within the range from 1.5 millimeters to 5 millimeters.

7. The woodwind instrument as set forth in claim **2**, in which said column is integral with said pad cup.

8. The woodwind instrument as set forth in claim **2**, in which said column is brazed to an inner surface of said pad cup.

9. The woodwind instrument as set forth in claim **1**, in which said deformable pad has a core layer formed of deformable material and a protective layer laminated on said core layer, formed of airtight material and receiving said force exerted by said fastener.

10. The woodwind instrument as set forth in claim **9**, in which said deformable material is compressed felt, and said airtight material is selected from the group consisting of skin and bladder.

11. The woodwind instrument as set forth in claim **9**, in which said fastener includes

a column formed with an internal thread and connected to said pad cup in such a manner to project into said recess,

a pad washer provided on said protective layer and formed with a hole and

a bolt having a head portion to be driven for rotation and a threaded stem portion loosely passing through said hole formed in said pad washer and held in threaded engagement with said internal thread so that said head portion is pressed to said pad washer.

12. The woodwind instrument as set forth in claim **11** in which said head portion and said pad washer respectively have a convex surface and a concave surface portion around said hole slidably in contact with said convex surface, and said convex surface and said concave surface portion as a whole constitute said automatic regulator.

13. The woodwind instrument as set forth in claim **12**, in which said concave surface and said concave surface portion form parts of a sphere, respectively.

14. The woodwind instrument as set forth in claim **13**, in which said sphere has a radius of curvature fallen within the range from 1 millimeter to 10 millimeters.

15. The woodwind instrument as set forth in claim **13**, in which said sphere has a radius of curvature fallen within the range from 1.5 millimeters to 5 millimeters.

16. The woodwind instrument as set forth in claim **11**, in which said column is integral with said pad cup.

17. The woodwind instrument as set forth in claim **11**, in which said column is brazed to an inner surface of said pad cup.

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